REMARKS

Reconsideration and allowance of this application are requested in view of the above amendment and the following discussion.

The present invention provides measurement of tension, vibration, temperature variations on the inside of a workpiece so that , as claimed, the optical fiber is integrated into the surface, or bonded to the surface of the workpiece. This feature is not shown by Ames. Additionally each of independent claims 1 and 12 recite the integration of the fibers 11-18 into recesses 31-38 in the surface of the workpiece. Neither Ames nor the references cited in the IDS's of August 25, 2003 or March 19, 2004 have these claimed features.

Claims 1-2, 5-13, 15-20 have been rejected under 35 USC 103 as unpatentable over the previously cited Ames patent (US 6,774,354). Applicants traverse this rejection on the grounds that each of independent claims 1 and 12 contain subject matter not shown, disclosed or made obvious by Ames or any other cited but not applied references.

Claims 1 and 12 require the optical fibers 11-18 to be "<u>integrated in the surface of the workpiece" 10 and recesses 31-38 which are "introduced into the surface of the workpiece".</u> Ames has a pitch sensor where the relative movement of the mass 16 (workpiece) being measured in relation to the cage 14 by Bragg sensors. As a result the optical fibers of Bragg are fixed to the cage 14 and must not be fixed (integrated) on the surface of the workpiece so that tension can be

generated in the optical fibers at gratings. If the optical fibres were bonded to the mass, tension would occur in the optical fibers at a location between the mass and the cage. Therefore in Ames the optical fibers must be mounted so as to be movable relative to the mass (workpiece). The optical fibers do not measure the tension on the surface of the mass or the cage.

The present invention in contrast provides and arrangement for measuring tension in the surface of a workpiece. The tension resulting from vibration, temperature changes or load in the surface are induced into the optical fibers which must be integrated into the surface.

Accordingly, not only does Ames fail to disclose the presently claimed invention but Ames also provides a disclosure which would not function if modified to meet the claim limitations fo the present invention as defined by independent claims 1 and 12 and the dependent claims 2, 5-11, 13 and 15-20 which depend from and contain all the limitations of either claim 1 or claim 12.

It is further noted that the Ames reference is similar to GB 2 136 119, a copy of which is attached as a courtesy. The '119 reference, similar to Ames, shows optical fibers 4 disposed in grooves 3 located on the body 2 but neither the fibers nor the grooves are integrated on the surface of the structure (workpiece) 5 as is required by the above discussed presently claimed invention. The '119 references is seen as merely cumulative of the Ames reference. According to 37 CFR 1.56(b) information is material to patentability when it is not cumulative.

The attach drawing of Fig. 1 now illustrated the recesses 31-38 for the optical fibers 11-18. The appropriate number insertion has been made to the specification. No new matter or new issues are raised by this change. Claim 9 has been amended to eliminate the objectionable grammar markings.

Therefore allowance of this application is requested in view of the claimed features which are not available from the references and which are not obvious from the references.

If there are any questions regarding this response or the application in general, a telephone call to the undersigned would be appreciated since this should expedite the prosecution of the application for all concerned.

If necessary to effect a timely response, this paper should be considered as a petition for an Extension of Time sufficient to effect a timely response, and please charge any deficiency in fees or credit any overpayments to Deposit Account No. 05-1323 (Docket # 011235.52686US).

Respectfully submitted,

February 21, 2006

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AMENDMENTS TO THE DRAWINGS:

The attached new sheet of drawings includes changes to Fig.1.

P 609 429/DE/1 (9)

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WO A1 82/03454

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G1A

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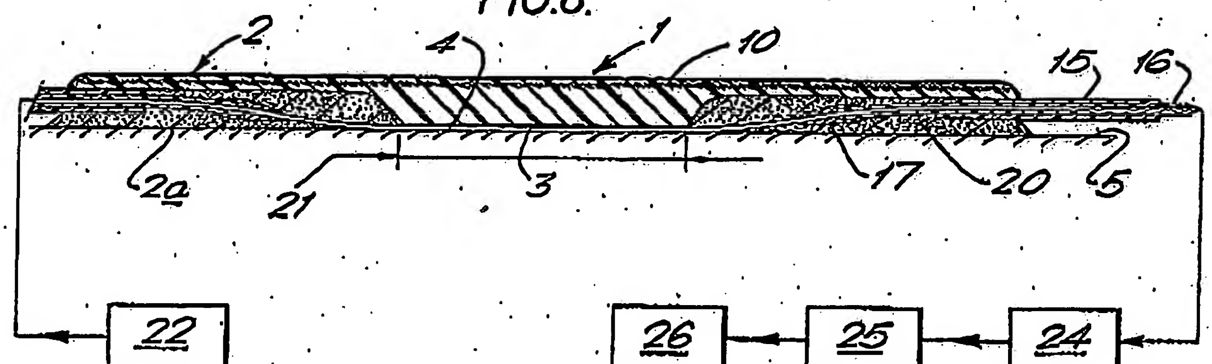
(54) **Crack Monitor**

(57) A crack monitor 1 comprises a translucent body 2 having a lower surface 2a defining a plurality of grooves 3. Optical fibres 4 are disposed in the grooves 3. When the body 2 is attached to a structure 5 to be monitored, with the fibres in close proximity to the structure, and with light transmitted through the fibres, light interruption caused by a crack in the structure, which propagates into the monitor, can be used to indicate the presence of a crack.

Light provided by a source 22, such as a light emissive diode or injection laser, is directed into one end of each fibre 4, the light transmitted therethrough being received by a detector 24. The output of which is connected to a level sensing device 25 which generates an alarm signal at a device 26 if ever the received level abruptly diminishes by an amount exceeding a predetermined threshold. The light source can be pulsed.

FIG.8.



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GB 2 136 119 A

- optische Faser
- kein Bragg-Gitter-Sensor (Detektion von Rissen durch Unterbrechung der Faser
- Fasern auf der Oberfläche des zu vermessenden Bauteils

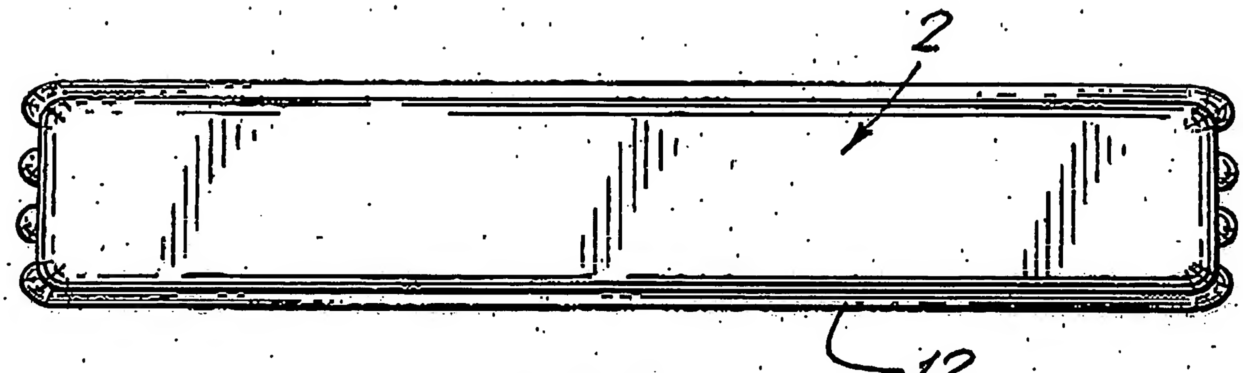


FIG.1.

FIG.2.

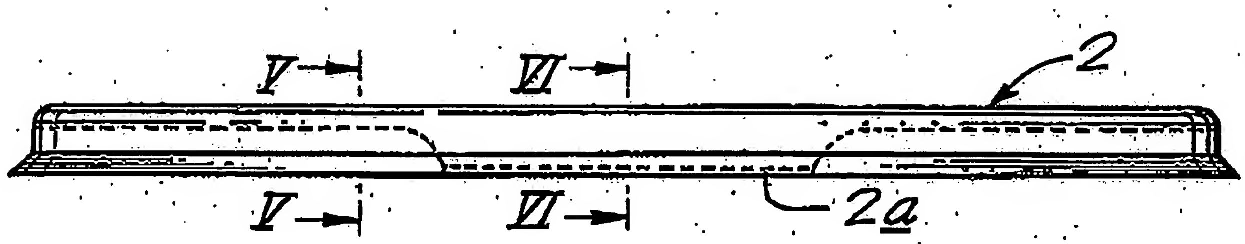
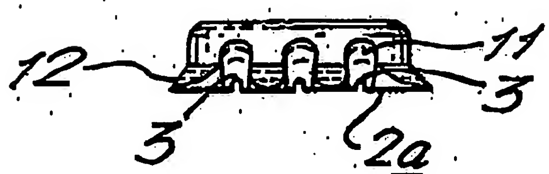


FIG.3.

FIG.4.



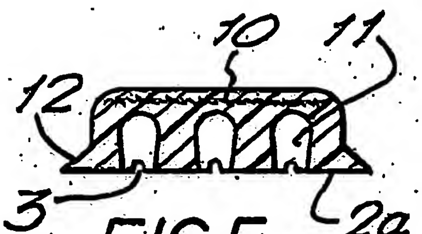


FIG.5.

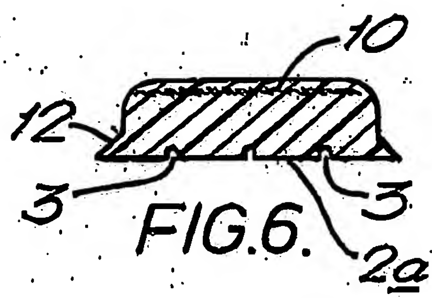


FIG.6.

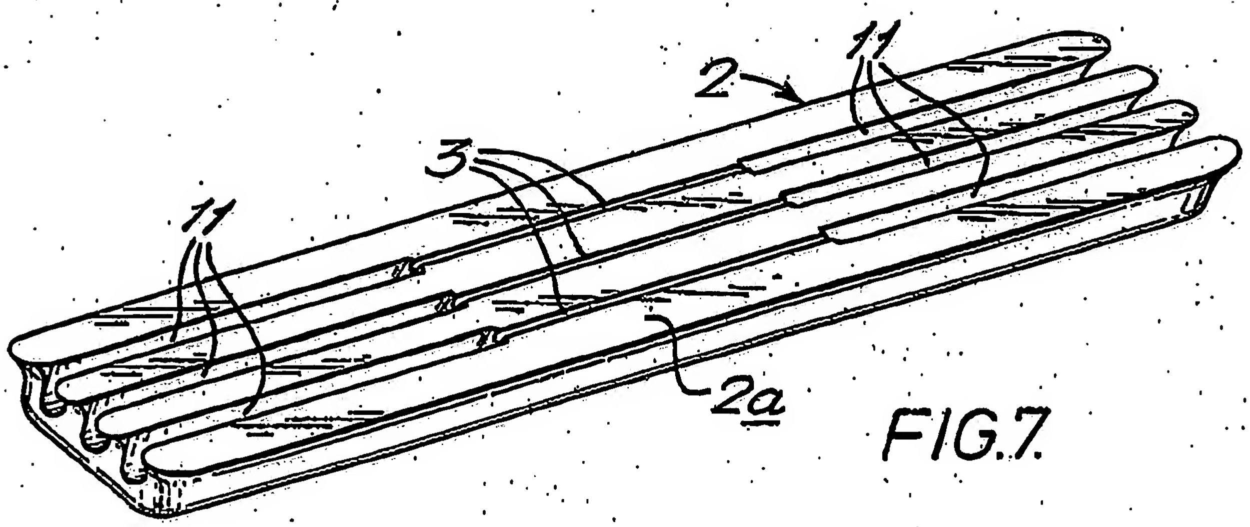


FIG.7.

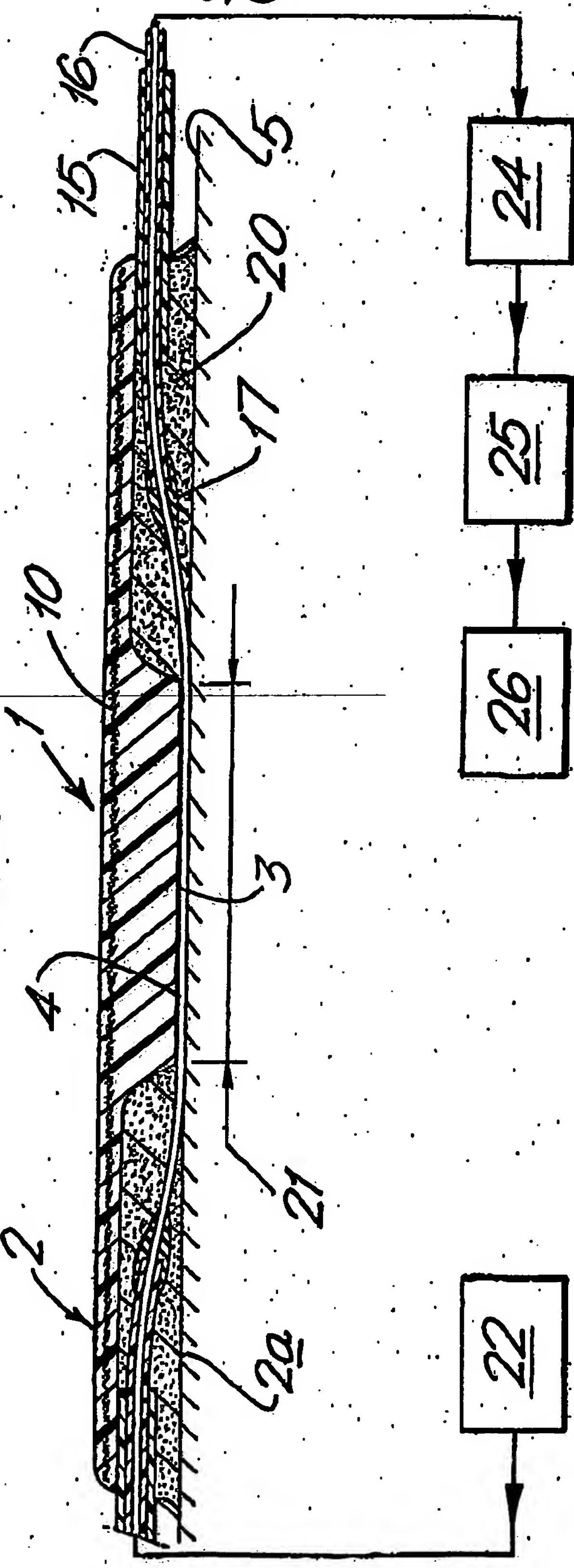


FIG.8.

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SPECIFICATION

Improvements in or Relating to Crack Monitors

Background of the Invention

This invention relates to crack monitors and is concerned with crack monitors which make use of fibre optics. A light source is provided at one end of a fibre and a light detector at the opposite end thereof. When a structure to which the fibre is attached is stressed sufficiently to fracture the fibre, the transmission of light is diminished. This loss of light can be used to generate an alarm signal.

The invention can also be used to monitor strain. Accordingly, as used herein, the term "crack monitor" is intended to include monitors for measuring strain as well as cracks.

Summary of the Invention

According to the invention, a crack monitor, (as defined herein), comprises a body having a surface defining at least one groove, and optical fibre(s) disposed in the groove(s), so that when the body is attached to a structure to be monitored, with the fibre(s) in close proximity with the structure, and with light transmitted through the fibre(s), light interruption caused by a crack in the structure can be used to indicate the presence of a crack.

Brief Description of the Drawings

An embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings, wherein:—

Figure 1 is a plan view of the crack monitor,

Figures 2, 3 and 4 are underneath, side and end views thereof,

Figures 5 and 6 are sections taken on the lines *V—V* and *VI—VI* of Figure 3,

Figure 7 is a view in perspective of the monitor (in an inverted position), and

Figure 8 is a side view, in longitudinal section, of the monitor, attached to a structure.

Detailed Description of the Preferred Embodiment

With reference to the figures, a crack (and strain) monitor 1 comprises a body 2 having a (lower) surface 2*a* defining a plurality of grooves 3, and optical fibres 4, (Figure 8 only), disposed in the grooves, so that when the body 2 is attached to a structure 5 to be monitored, with the fibres in close proximity to the structure, and with light transmitted through the fibres, light interruption caused by a crack in the structure, which propagates into the monitor, can be used to indicate the presence of a crack.

The body 2 comprises an epoxy resin or other translucent premould, using a casting material which suits the working environment, and which provides some flexibility. A suitable resin is of the epoxy group, using an amine based catalyst, for example, "M/BOND AE-10", a two-part epoxy adhesive manufactured by the Micro-Measurements Division, Measurements Group Inc., P.O. Box 27777, Raleigh, North Carolina, U.S.A., obtainable from Welwyn Strain Measurements Limited, Basingstoke, Hampshire, England. Alternatively, "Permabond (R.T.M.) E30", obtainable from Permabond Limited of Eastleigh, Hampshire, England, or "Silverlock (R.T.M.) 1401, 1701 or 1901", obtainable from BTR Development Limited, Burton-on-Trent, England. Choice of resin will depend on operating conditions.

The body 2 could be made by injection moulding.

Alternatively, the body 2 comprises a resin-impregnated paper, such as "Nomex" (Registered Trade Mark) material, used for insulation purposes in the manufacture of electrical transformers, or a "pre-preg" (i.e. a component previously impregnated with resin), comprising glass of carbon fibre reinforcement incorporated into a mass of heat curable epoxy resin, for example "Fibredux" (R.T.M.), which is obtainable from Ciba-Geigy, Duxford, Cambridgeshire, England.

The body 2 of the present example incorporates a fibreglass scrim 10, but this can sometimes be dispensed with.

The body surface 2*a* defines, (in this example), three laterally-spaced grooves 3. The grooves 3 extend in substantially parallel array, into slots 11 of much larger cross-section, which have tapering walls, as best shown in Figures 4 and 5.

The body 2 of the example is provided with an outwardly extending skirt portion 12 which extends around the whole of the periphery of the body 2, except for the ends of the slots 11.

The body 2 could be shaped so as to conform with the shape of structure being monitored. For example, it could be shaped so as to be disposed across the line of a weld, in contiguous relationship with the weld.

The ends of the optical fibres 4 are enclosed in sleeves 15 of polyvinylchloride (P.V.C.), Nylon or other suitable polymer, with epoxy buffers 16. The sleeves 15 are a push fit into the slots 11, the tapering walls thereof holding the sleeves securely. The ends of the fibres 4 are made to curve slightly, within the slots 11, so as to accommodate any bending of the body 2. An index matching compound 17 is used here to secure the ends of the fibres 4 to the buffers 16 and to minimise light loss at the discontinuity, but it may be possible to dispense with this. A suitable matching compound is a single component polymer having a low refractive index, for example, "EPO-TEK" (μ=1.394), manufactured by Epoxy Technology Incorporated, U.S.A.

The optical fibres 4 are carefully "clipped" in place within the grooves 3, using a minimal amount of adhesive to ensure precise location.

The "package" provided by the body 2, fibres 4 etc., is applied to the structure 5 under controlled pressure, using adhesive 20. For application to curved surfaces some pre-heat may be required. The active region of the fibres 4, i.e. the region of

the contiguous relationship between the fibres 4 and the structure 5, is indicated at 21.

Greater sensitivity is obtained when the body 2 is placed obliquely across the anticipated crack.

With further reference to Figure 8, in use, light from a source 22, such as a light emissive diode or injection laser, is directed into one end of each fibre 4 and the light transmitted therethrough is received by a detector 24. The output of the detector 24 is connected to a level sensing device 25 operable to generate an alarm signal at a device 26 if ever the received level abruptly diminishes by an amount exceeding a predetermined threshole. The light source does not need to be operated continuously, but can be pulsed.

When the light path is broken or otherwise interrupted, arising from when a crack initiates, or strain occurs, either on the surface of the structure 5 or within the bulk thereof, not only does attenuation of the light signal cause an alarm signal to be triggered, but light caused to scatter by fracture of a fibre 4 provides a visual indication of where the crack (or strain) exists.

The above-described system makes use of visible light at all times. In a preferred modification, source 22 provides alternatives of infra-red and visible light, and detector 24 is sensitive only to infra-red light.

In use, infra-red light is initially employed. However, once alarm device 26 is brought into operation, source 22 automatically is caused to emit visible light whereby a visual indication of a fracture fibre is immediately provided.

Use of infra-red instead of visible light for crack and strain monitoring purposes has distinct advantages, including the ready availability (and relative cheapness) of infra-red sources and detectors.

It will be appreciated that the monitor 1 may be modified so as to make use of any desired number of optical fibres. Typically, bundles of three, seven or nineteen fibres may be used to achieve generally circular grouping of fibres within optical fibre cabling.

The grooves 3 need not be linear.

A sandwich-like "package" may be constructed, by laying down a thin (e.g. 10 micron) skin of heat-curable "pre-preg" (see above) material, followed by one or more optical fibres, and then another thin (e.g. 10 micron or more) heat-curable "pre-preg" skin. The whole is then subjected to pressure and heat. The application of pressure causes the fibres to form their own grooves in the surrounding body of "pre-preg" material.

This method of manufacture is particularly suited to large-scale production.

The optical fibres used are originally provided with primary and secondary coatings. In order to provide a really sensitive monitor it is desirable to remove these coatings. However, once this is done the fibres immediately become vunerable to attack by water in the atmosphere. The method of manufacture just described encapsulates the bared fibres and thus protects them.

Although, in use, the optical fibres of the package are no longer in contact with a surface being monitored; they remain in close proximity thereto, being separated only by the first mentioned skin of "pre-preg" material.

CLAIMS

1. A crack monitor (as defined herein) comprising a body having a surface defining at least one groove, and optical fibre(s) disposed in the groove(s), so that when the body is attached to a structure to be monitored, with the fibre(s) in close proximity with the structure, and with light transmitted through the fibre(s), light interruption caused by a crack in the structure can be used to indicate the presence of the crack.

2. A crack monitor as claimed in Claim 1, wherein the body is translucent.

3. A crack monitor as claimed in Claim 1 or 2, wherein the body is of a casting material.

4. A crack monitor as claimed in Claim 1 or 2, wherein the body comprises a resin-impregnated paper.

5. A crack monitor as claimed in Claim 1 or 2, wherein the body comprises glass or carbon reinforcement incorporated into a mass of plastics material.

6. A crack monitor as claimed in any one of Claims 1 to 5, wherein said groove(s) is/are linear.

7. A crack monitor as claimed in any one of Claims 1 to 5, wherein a plurality of grooves are provided, said grooves extending in substantially parallel array.

8. The combination of a crack monitor as claimed in any one of Claims 1 to 7, light source means at one end of the fibre(s), light detector means at the other end of the fibre(s) and light sensing means operable to generate an alarm signal if the received level of light abruptly diminishes by an amount exceeding a predetermined threshold.

9. A crack monitor substantially as hereinbefore described with reference to the accompanying drawings.

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